AD-A061 865 AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB OHIO F/G 6/14
AMRL'S PILOT STRENGTH AND ENDURANCE SCREENING. PROGRAM,(U)
MAY 78 J W MCDANIEL
UNCLASSIFIED AMRL-TR-78-112 NL

| OF |
AD
A061865

END
DATE
FILMED
2-79
DDC

ADA061865

DDC FILE COPY

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER: 14 AMRL-TR-78-112 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle): 6 AMRL's PILOT STRENGHT AND ENDURANCE SCREENING PROGRAM, 9 | | 5. TYPE OF REPORT & PERIOD COVERED: PREPRINT |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s): 10 JOE W. McDANIEL Ph.D. | | 8. CONTRACT OR GRANT NUMBER(s): 17 08 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: AEROSPACE MEDICAL RESEARCH LABORATORY, AEROSPACE MEDICAL DIVISION, AIR FORCE SYSTEM COMMAND, WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 16 62202F 71840831 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | | 12. REPORT DATE: 11 MAY 1978 |
| | | 13. NUMBER OF PAGES: 3 12 5p. |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 15. SECURITY CLASS. (of this report): UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED



17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

ORAL PRESENTATION PRESENTED AT AEROSPACE MEDICAL ASSOCIATION, HILTON HOTEL, NEW ORLEANS, LA 7-12 MAY 1978

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

PILOT PERFORMANCE
MUSCULAR ENDURANCE
MUSCULAR STRENGTH
MALE - FEMALE
TEST



20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

009 850

78 11 03

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

JDB

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AEROSPACE MEDICAL RESEARCH LABORATORY'S
PILOT STRENGTH AND ENDURANCE SCREENING PROGRAM

Joe W. McDaniel
Aerospace Medical Research Laboratory
Aerospace Medical Division, Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

The United States Air Force has recently begun accepting women into the pilot training program. Since women are prohibited from flying aircraft which have a combat mission, the aircraft available to women are mostly the multi-engine transport type. The 19 aircraft currently available for assignment to female pilots are C-135, VC-131, EC-121, C-140, VC-137, C-9, C-141, C-12, C-5, E-4, WC-130, UH-1, U-4, T-43, T-41, T-39, T-38, T-37, and T-33.

The design standards for aircraft control resistance have evolved over a period of years based on the experience and performance of male pilots in the mission environment. Reliable performance here can only be defined in terms of the mission environment. It must be recognized that the existing standards for aircraft design and existing aircraft have male pilot performance capabilities as their baseline. There have been necessary trade-offs which have, in many cases, resulted in control characteristics which are marginally operable by male pilots under extreme conditions.

In October of 1976, a two-phased program was defined by AMRL. The Phase I effort was a preliminary effort to (A) define female strength and (B) accumulate data on control actuation forces. The Phase II effort will develop, deploy, and validate a strength measuring technique for screening pilot candidates. This phase consists of comprehensive studies to (A) measure relevant pilot strength characteristics, (B) evaluate unknown aircraft control force characteristics, (C) design and construct screening apparatus, and (D) validate the screening apparatus.

## RESULTS OF PHASE I - PROBLEM IDENTIFICATION

The purpose of Phase I of the Pilot Strength Screening Program was to determine the scope and magnitude of the problem, if any. After surveying a number of sources as described below, it was determined that an increase in risk would occur if the physical strength and endurance of future pilots were significantly below that of the present population of male pilots. AMRL-TR-73-32, "Muscular Strength of Men and Women: A Comparative Study," is an extensive review of muscle strength literature involving strength measures for which comparable data exist for both men and women. The data show that the "overall" total body strength of women as compared to men is about 63.5%; however, this value may range from 35 to 86%. Static strength in the upper extremities of women were found to be 59.5% that of men with a range of 47 to 79%. Women's trunk strength was found to be 63.8% that of men with a range of 37 to 70%. The dynamic strength characteristics, which included lifting, lowering, pushing, and pulling tasks, of women were found to average 68.6% that of men, ranging from 59 to 84%.

An FAA study titled, "Study of Control Force Limits for Female Pilots," involved 24 female pilots selected by age, weight and height to represent the population of female civilian pilots. These results provide some guidance as to how long (in seconds) female subjects could exert a given force on a particular aircraft control. These data indicate extremely broad ranges of endurance, ranges as low as two seconds for holding 55 pounds of elevator, 12 seconds for 22 pounds of aileron, and one second for 150 pounds of rudder. These levels of endurance are not adequate to fly large, multi-engine aircraft.

The aircraft specifications permit the following simultaneous control resistances:

| Type Control | Elevator | Aileron | Rudder |
|---|---|---|---|
| Stick | 50 pounds | 25 pounds | 175 pounds |
| Wheel | 75 pounds | 40 pounds | 175 pounds |

The duration of these forces is not specified, although duration is as critical as the quantity of force. All aircraft were not built to these standards, however, and some requirements were waived when solutions were costly. Data compiled by the Flight Controls Branch of ASD Deputy for Engineering show that many aircraft control forces exceed the current specification. It was also reported that some male pilots have had control problems.

This is not to say that women cannot or should not fly. During WW-II, the famous WASPS (Women Air Service Pilots) performed exceptionally as ferry pilots and in target towing. These were not average women, however. All applicants had a minimum of 200 hours of civilian pilot experience. More than 92 percent of applicants were rejected in rigorous screening. Of these accepted for training, 40 percent washed out prior to graduation. With the current high cost of training military pilots, ($238,000 for each undergraduate pilot trainee) our purpose in developing a strength and endurance screening procedure is to avoid the costs and safety implications associated with using pilot training itself as a screening procedure.

An interview study of 22 USAF transport pilots has verified that endurance of submaximal forces either repeatedly or for a long period of time is common. These pilots have had experience in 11 of the 19 candidate aircraft, and as a group have piloted 26 different Air Force aircraft. This experience provided a basis for comparing the relative difficulty of flying these aircraft. The consistency of responses among these pilots gives cause to accept them as valid. The majority of pilots had over 2000 flying hours and many were test and instructor pilots. The consensus is that the transport type aircraft (C-141, C-135, C-130, etc.) require many times the control force of trainers (T-37, T-38) or fighter type aircraft. Particularly, conditions such as out-of-trim, failed hydraulics, and engine out; and maneuvers such as cross-wind landing, extending flaps, dive recovery and engine run-up; require large forces on the controls for extended periods of time or repeatedly to the extent that physical fatigue can be a limiting factor. The endurance of submaximal forces was frequently described as the limiting factor, rather than brief exertion of maximum strength.

The results of the Phase I investigation led to the conclusion that persons of relatively less strength and endurance may not be able to pilot some of the larger aircraft under adverse control conditions with a high degree of performance and safety. The Phase II effort to develop a strength and endurance screening procedure has been initiated and is underway at AMRL.

PHASE II - DEVELOPMENT OF SCREENING PROCEDURE

The purpose of Phase II is to develop, deploy, and validate a strength measuring technique for screening pilot candidates. Because of the range of size and sophistication of the candidate aircraft, it is expected that there will be a considerable range of forces required to operate their controls. This study will consider the static and dynamic strength and endurance capability for each of the major controls: stick, wheel, rudder and ejection controls; both individually and in appropriate combination. Because the screening procedure will have a duration much shorter than the typical aircraft mission, a time compressed test must be devised. A comprehensive strength study is necessary to establish these compression factors so that the screening procedure will be a valid prediction of pilot performance. This strength study is important not only to the development of a strength screening device, but also to the future design and evaluation of USAF systems. A thorough effort here will continue to draw dividends for many years.

Two pilot configuration strength testing devices acquired from the Navy are currently being modified for this study. One of these devices has a wheel-type controller and rudder pedals, while the other has a stick-type controller with a collective and rudder pedals. New control linkages are being fabricated to allow direct measurement of forces on the controls. These devices employ pneumatic cylinders to provide a passive, variable spring resistance to control movement.

The first series of experiments will be concerned with the comparative strength of male and female subjects tested on traditional aircraft controls: stick, wheel, rudder, and collective. Since the stick and wheel controllers are operated by different sets of muscles, these studies will try to establish a predictive relation between performance on these two controls. The relation between body size and strength will be another variable of study.

In addition to the two cockpit simulators, a third apparatus is being constructed with a wheel-type controller and rudder pedals. The controls of this device will be attached to powerful mechanical actuators so that active and dynamic control resistances can be created and measured in real-time by means of a digital data collection system. The major difference between this and the other devices is that the controls will move on command from the micro-processor based automatic data collection system. In this way, a control feed-back loop can be generated under program control to cause the rate of control movement to be a function of the force the subject is exerting on the controls allowing the work output of the subject to be measured directly. This device will also permit isokinetic force measurements with the aircraft configuration controls. As a laboratory research tool, the device will be versatile and efficient, allowing almost any active or reactive control situation to be created.

The test device which will be deployed in the field will probably have many of these same features. An inexpensive micro-processor will completely control the test apparatus. The subject will be automatically cued to perform; the control resistances will be adjusted; the strength and endurance measures recorded; the measures will be reduced; and the final test scores printed by the device itself. In this way, the test procedures can be complex and sophisticated, while procedural irregularities, data reduction errors, and data transcription errors will be prevented. Once the strength characteristics of the operators and the strength requirements of the aircraft are known, the design of the pilot screening device can be completed. The characteristics of this device must simulate the appropriate range of aircraft control locations, resistances, damping, and force/displacement profiles to provide a prediction of the subject's capability to perform the missions of the aircraft. The device must measure endurance as well as strength, and will probably require a time-compressed endurance test to predict performance of missions which may last several hours.